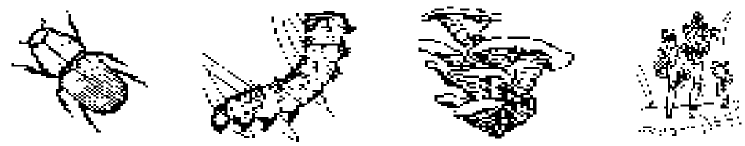
Forest Health Protection



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UPDATE ON LIMBER PINE DECLINE AND MORTALITY ON THE LEWIS AND CLARK NATIONAL FOREST, MONTANA

Marcus Jackson and Blakey Lockman
Plant Pathologists

INTRODUCTION

This report updates a study that was undertaken to identify causes of limber pine decline and mortality in central Montana (Taylor and Sturdevant 1998). Taylor and Sturdevant determined that 85% of the mortality along permanent transects in the Lewis and Clark National Forest from 1995 through 1998 was associated with defoliation from the needle pathogen *Dothistroma septospora* (Doroguine) Morelet. Although 41% of the study trees were reportedly infected with the white pine blister rust pathogen *Cronartium ribicola* Fisch, Taylor and Sturdevant believed rust-caused mortality was low, accounting for only 12% of the total mortality. The remaining mortality, approximately 3%, was attributed to suppression.

METHODS

Transect establishment methods are described in the earlier report (Taylor and Sturdevant 1998). Four transects were established in the Lewis and Clark National Forest. Trees were tagged to allow monitoring over time. From 1996 to 1998, all tree and site data were taken according to USDA Forest Service, Northern Region stand exam guidelines.

Data has been collected three times (1999, 2000, and 2002) since the first report was printed. All four transects were visited in July of 1999 and 2002. During 2000, Dry Wolf and Yogo Town were visited in June and Lick Creek and Ettien Ridge were visited in October.

Beginning in 1999, a standardized form documenting percent crown affected by *D. septospora*, blister rust severity level, and mortality was used. Needle retention data were collected in 2002.

Precipitation data from five weather stations within an approximate radius of 35 miles around the transects were included in the analysis of disease development and mortality. Data for “Neihart 8NNW,” “Millegan 14SE,” “White Sulphur Springs 2,” “Raynesford 2NNW,” and “Stanford” weather stations were taken from the Western Regional Climate Center’s web page at www.wrcc.dri.edu/index.html.

Throughout this report, “severe” means 90% or more of the foliage in a given crown is affected by *D. septospora*. “Non-severe” means less than 90% of the foliage is affected by *D. septospora* in a given crown.

RESULTS

Mortality associated with *D. septospora* severity

Trees with severely affected crowns were more likely to die in subsequent years than non-severely affected trees in the same year. Table 1a shows mortality through 2002 associated with defoliation data collected in 1999, while Table 1b shows mortality through 2002 associated with severe defoliation in both 1999 and 2000. Thirty-eight percent of the Dry Wolf trees and 27% of the Yogo Town trees with severely

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affected crowns in 1999 died by 2002 (Table 1a). Forty-three percent of the Dry Wolf and 28% of the Yogo Town trees with severely affected crowns in both 1999 and 2000 died by 2002 (Table 1b). No trees with less than 90% of their crowns affected at the Dry Wolf and Yogo Town transects in 1999 and 2000 died by 2002. Three percent of the trees at Lick Creek and 7% of the trees at Ettien Ridge with non-severely affected crowns in 1999 died by 2002. For those trees with severely affected crowns in 1999, 60% and 56% of them died at Lick Creek and Ettien Ridge, respectively. In 2000, there was only one tree affected by 90% defoliation at Lick Creek and none at Ettien Ridge. Six percent of the trees at Lick Creek and 10% of the trees at Ettien Ridge with non-severely affected crowns in 1999 and/or 2000 died by 2002.

Table 1a. Comparison of 1999 *D. septospora* Severity to Mortality through 2002

Transect	Non-severely Affected Crown in 1999		Severely Affected Crown in 1999	
Lick Creek	1/31[1]	3%	3/5[2]	60%
Ettien Ridge	3/42	7%	5/9	56%
Dry Wolf	0/0	0%	13/34	38%
Yogo Town	0/6	0%	15/56	27%
Total	4/79	5%	36/104	35%

[1]Dead trees in 2002/# of live trees with <90% of the crown affected in 1999.
[2]Dead trees in 2002/# of live trees with 90 to 100% of the crown affected in 1999.

Table 1b. Comparison of Two-Year[1] *D. septospora* Severity to Mortality through 2002

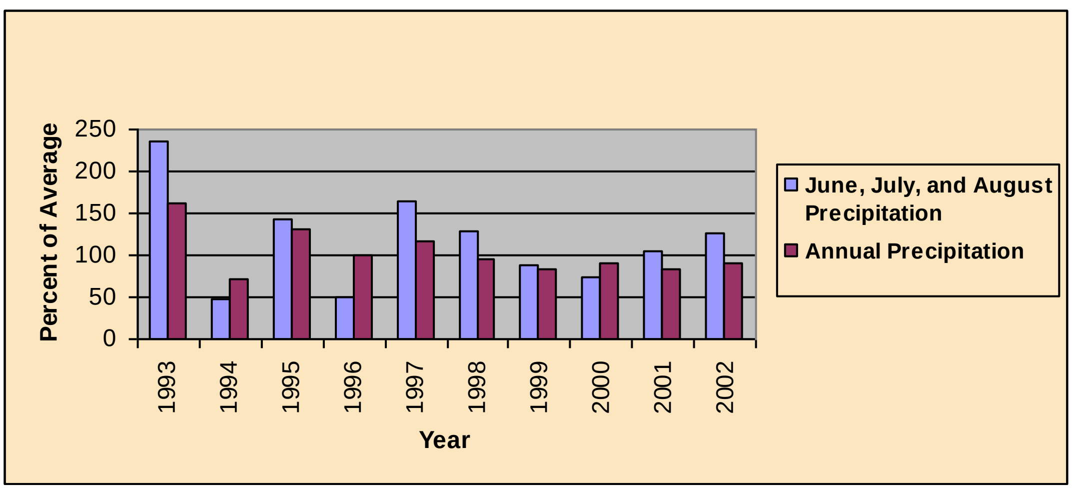
Transect	Mortality[2]	Non-Severely Affected Crown		Severely Affected Crown	
Lick Creek*	2	2/32[3]	6%	0/1[4]	0%
Ettien Ridge	3	5/48	10%	0/0	0%
Dry Wolf*	1	0/4	0%	12/28	43%
Yogo Town	3	0/16	0%	12/43	28%
Total	9	7/100	7%	24/72	33%

[1]Crown affects for 1999 and 2000.
[2]Number of trees that died from 1999 to 2000.
[3]Dead trees in 2002/# of live trees with <90% of the crown affected in 1999 and/or 2000.
[4]Dead trees in 2002/# of live trees with 90 to 100% of the crown affected in both 1999 and 2000.
*Lick Creek and Dry Wolf transects were each missing 1 year of data for one tree

Precipitation

Precipitation at any time during the growing season may provide for *D. septospora* spore dissemination and infection of susceptible needles (Taylor and Schwandt 1998). Combined data* from the five weather stations showed higher average precipitation in June, July, and August of 1993 (235% of average), 1995 (144% of average), 1997 (164% of average), 1998 (129% of average), and 2002 (127% of average) than the average (Figure 1). Precipitation combined for June, July, and August in 1994, 1996, 1999, 2000, and 2001 remained near or below average. The effect of drought-like conditions following defoliation may cause greater mortality than defoliation alone. Annual precipitation was 12% below average at the weather stations when precipitation data were combined and averaged over the 4-year period from 1998 through 2001. During the 4-year period from 1994 through 1997, combined annual precipitation at the four weather stations was 4% above average.

Figure 1. Average precipitation for growing season compared to average annual precipitation, 1993-2002.



*The "averages" are the means for the entire reporting period for each weather station (ranging from 19 to 38 years depending on the weather station).

Needle retention

Needle retention data were collected in 2002 (Table 2). Needle retention displayed an inverse relationship to previous *D. septospora* infections. While approximately three-fourths of the trees at Lick Creek and Ettien Ridge retained 3 or 4 years of their needles, approximately 3/4 of the trees at Dry Wolf and Yogo Town retained only 2 years of their needles. All trees, except 1, retained 2 or more years of their needles.

Table 2. Needle retention in 2002

	Years Retained[1]					
Transect	1	2	3	4	5	Median
Lick Creek	0 (0)[2]	6 (19%)	15 (47%)	8 (25%)	3 (9%)	3
Ettien Ridge	0 (0)	8 (19%)	12 (28%)	23 (54%)	0 (0)	4
Dry Wolf	0 (0)	16 (76%)	5 (24%)	0 (0)	0 (0)	2
Yogo Town	1 (2%)	38 (81%)	8 (17%)	0 (0)	0 (0)	2

[1]The average age of the oldest needles retained throughout the crown of each tree.

Decreasing damage from *D. septospora*

The average "percent crown affected" by *D. septospora* for each transect was determined by adding together the "percent crown affected" of all the live trees in the transect and dividing that number by the total number of live trees in the transect. Since 1999, there has been a substantial and continual decrease in the levels of *D. septospora* on all four transects (Table 3).

Table 3. Percent crown affected by *Dothistroma septospora*[1]

Transect	1999	2000	2002
Lick Creek	53%[2]	33%	7%
Ettien Ridge	51%	12%	0%
Dry Wolf	98%	94%	24%
Yogo Town	95%	84%	40%
Average	75%	56%	18%

[1]All live trees averaged across each transect.
[2]Average percent for all the live crowns at the transect for the given year.

White Pine Blister Rust

From 1998 to 1999, there was a reduction in the number of trees reported to be infected with *C. ribicola* at three transects (Table 4a). The reduction was likely due to changes in crew, monitoring methods, and inconsistencies described below for 1999 through 2002 data.

Table 4a. Incidence of *C. ribicola* (including all Rust Severities)

Transect	1998 (%)	1999 (%)	2000 (%)	2002 (%)
Lick Creek	20/37[1] (54)	19/37 (51)	31/34 (91)	27/32 (84)
Ettien Ridge	19/53 (36)	26/51 (51)	36/48 (75)	23/43 (54)
Dry Wolf	14/36 (39)	0/34 (0)	3/33 (9)	4/21 (19)
Yogo Town	24/63 (38)	3/62 (5)	19/59 (32)	27/47 (57)

[1]Number of infected trees/total number of live trees at the transect (percent of total live trees infected).

Rust Severity Classes:

1. Branch infections located greater than 2 feet from bole
2. Branch infections located 6 inches to 2 feet from bole
3. Bole infections or branch infection within 6 inches of bole
4. Topkill from rust

There are many irregularities in the blister rust data from 1999 through 2002. Two cankers noted in 1999 were missed in 2000, then again noted in 2002. Twenty-one cankers were noted in 1999 and/or 2000, but not noted on live trees in 2002. Many irregularities appear to originate from the identification of rust cankers more than 2 feet from the bole of the tree (Rust Severity 1). When Rust Severity 1 data is removed from the incidence data, there appears to be a continued increase in the numbers of trees that are infected with blister rust at each transect since 1999 (Table 4b).

Table 4b. Incidence of *C. ribicola*[1] (not including Rust Severity 1)

Transect	1999 (%)	2000 (%)	2002 (%)
Lick Creek	18/37[2] (49)	16[3]/34 (47)	22/32 (69)
Ettien Ridge	11/51 (22)	14/48 (29)	18/43 (42)
Dry Wolf	0/34 (0)	1/33 (3)	3/21 (14)
Yogo Town	3/62 (5)	5/59 (8)	20/47 (43)
Total	32/184 (17)	36/174 (21)	63/143 (44)

[1]Rust Severities 2, 3, and 4 are included. Rust Severity 1 data was irregular across the 3 years.
[2]Number of infected trees/total number of live trees at the transect (percent of total live trees infected).
[3]The decrease in incidence is caused by two blister rust infected trees dying between 1999 and 2000.

Mortality

Annual mortality (Taylor and Sturdevant 1998) decreased in all transects from 1997 to 1998 (Table 5). Mortality remained under 10% for each year through 2002 at Lick Creek and Ettien Ridge. There was a considerable increase in mortality at Dry Wolf and Yogo Town over the last two years. Mortality remained under 10% from 1998 through 2000, but averaged 18% at Dry Wolf and 10% at Yogo Town annually in 2001 and 2002 (2-year combined mortality equally divided between the 2 years).

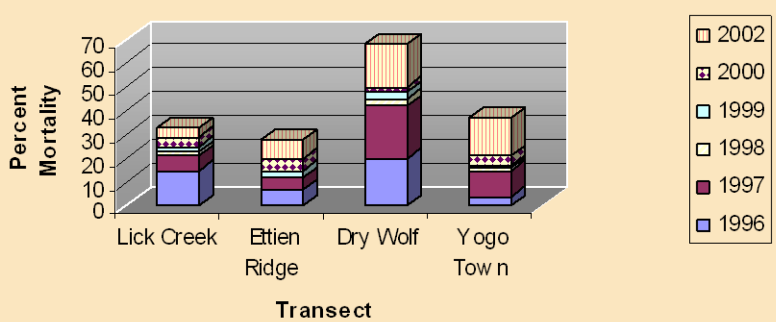
Table 5. Summary of mortality

Transect	Annual tree mortality[1]						
	1996	1997	1998	1999	2000	2002[2]	Total[3]
Lick Creek	7/48 (15)	3/41 (7)	1/38 (3)	1/37 (3)	2/36 (6)	2/34 (6)	16/48 (33)
Ettien Ridge	4/60 (7)	3/56 (5)	0/53 (0)	2/53 (4)	3/51 (6)	5/48 (10)	17/60 (28)
Dry Wolf	13/65 (20)	14/52 (27)	2/38 (5)	2/36 (6)	1/34 (3)	12/33 (36)	44/65 (68)
Yogo Town	3/75 (4)	8/72 (11)	1/64 (2)	1/63 (2)	3/62 (5)	12/59 (20)	28/75 (37)
Total	27/248 (11)	28/221 (13)	4/193 (2)	5/189 (3)	10/184 (5)	31/174 (18)	105/248 (42)

[1]Number of trees that died since previous visit/number of live trees at previous visit of transect (% of live trees).
[2]Percent mortality in 2002 is the accumulated mortality of two years (2001 and 2002).
[3]Cumulative mortality on each transect over entire study period.

Since the study began, mortality has been 33%, 28%, 68%, and 37%; respectively, for Lick Creek, Ettien Ridge, Dry Wolf, and Yogo Town (Figure 2). At the Dry Wolf and Yogo Town transects, all mortality from 1999 through 2002 was associated with greater than 90% of each crown affected by *D. septospora*. Three of the four trees that died at Lick Creek during this period were associated with severe crown effects. Two of the eight trees that died at Ettien Ridge were also associated with high levels of *D. septospora*.

Figure 2. Percent mortality for each transect for each measurement year.



DISCUSSION

Needle Cast (*Dothistroma septospora*)

Taylor and Sturdevant (1998) attributed 85% of the mortality along the transects to *D. septospora*, 12% to *C. ribicola*, and 3% to suppression. Our results support their findings, as we have shown that 80% of the mortality was associated with *D. septospora* since 1999. This study shows greater subsequent mortality when 90% or more of a tree's crown was affected by *D. septospora* than trees with less than 90% of their crowns affected. Increased precipitation during the growing season of 1993, 1995, 1997, and 1998 may have contributed to *D. septospora* dissemination, germination, and infection from 1996 through 2000.

Taylor and Sturdevant (1998) suggested that limber pine may be less able to withstand defoliation because of the hot, droughty conditions on south-facing slopes. There was more mortality on the transects of the south-facing slopes (Dry Wolf, Yogo Town) than the transects on the west and northwest-facing slopes (Lick Creek, Ettien Ridge). However, the south-facing slopes also had more defoliation associated with *D. septospora* than the west and northwest-facing slopes. This suggests that the conditions on the south-facing slopes in this study may have been more conducive to infection or the trees on these slopes may have been more susceptible to infection by *D. septospora*.

Even though the levels of *D. septospora* declined since 1999, mortality has increased on the Yogo Town and Dry Wolf transects. Inadequate soil moisture may have prevented many of the previously heavily defoliated trees from recovering.

Retention of 2 or more years of needles and declining rates of defoliation suggest the effects of *D. septospora* infections may be waning on the transects. However, since much remains unknown about the biology of this fungus in limber pine, we cannot reliably predict the future effects this fungus will have on these stands.

White Pine Blister Rust *(Cronartium ribicola)*

Limber pine are more likely to have multiple leaders than some other 5-needled pines. Due to the presence of several stems, individual stem infections are less likely to be lethal. This is one reason that the white pine blister rust rating system does not perform well for limber pine.

This study shows the difficulty in identifying white pine blister rust on limber pine. Some year-to-year variability could have been caused by differences in observers' abilities to see and properly identify blister rust cankers. The high number of missed cankers and/or previously misidentified cankers suggests there may be another canker fungus or other biotic or abiotic problem causing symptoms similar to early blister rust infections. Another possible explanation is that some of these cankers were produced on trees that responded to the cankers with "bark resistance reactions" as has been seen on other 5-needled pines, but this is unlikely due to the low level of resistance observed in natural populations of western white pine (Bingham 1983).

Although there were many inconsistencies in rating white pine blister rust, the data support the conclusion that *C. ribicola* was a minor factor in the overall mortality on the transects from 1999 through 2002. However, the incidence of blister rust appears to have continually increased since 1999 and may be an increasingly important factor contributing to mortality in the future.

LITERATURE CITED

Bingham, R.T. 1983. Blister rust resistant western white pine for the Inland Empire: The story of the first 25 years of the research and development program. USDA For. Serv. GTR INT-146. Ogden, UT. 45p.

Taylor, J.E. and N. Sturdevant. 1998. Limber pine mortality on the Lewis and Clark National Forest, Montana. USDA For. Serv. Forest Health Protection Rpt. 98-5. Missoula, MT. 7p.

Taylor, J.E. and J.W. Schwandt. 1998. Dothistroma needle blight of limber pine in Montana. USDA For. Serv. Forest Health Protection Rpt. 98-4. Missoula, MT. 7p.

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